© 2015 IJEDR | Volume 3, Issue 4 | ISSN: 2321-9939

Short Term Load Forecasting Of Chhattisgarh Grid Using Artificial Neural Network

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***Abstract-* Electrical load forecasting is the process of predicting future electrical load demand on the basis of given historical load information. Load forecasting is an essential and integrated process in planning and operation of electric power utilities. The basic quantity of interest in load forecasting is typically the time period in relation to the load demand studied. Power sector is highly capital intensive and entire planning of generation, transmission and distribution follows an axiomatic approach based on load forecasting. Short-term load forecasting is used in power system for real-time control, security, optimal unit commitment, economic scheduling, maintenance, energy management and power-plant structure planning etc. In this research work Short-Term Load Forecasting of Chhattisgarh Grid is done by using the data obtained from State Load Dispatch Centre (SLDC) of Chhattisgarh State Power Transmission Company Limited (CSPTCL). Artificial Neural Network (ANN) is used in MATLAB to train, test and simulate the data obtained from SLDC Chhattisgarh.**

***Index Terms-* Short Term Load Forecasting, State Load Dispatch Centre, Artificial Neural Network, Training, Testing, Simulation, Feed Forward Back Propagation, Mean Absolute Percentage Error.**

I. INTRODUCTION

A prediction scenario of future events and situations is called as forecast, and the act of making such predictions is called forecasting. Forecasting is the basic technique of decision making in different areas of life. The purpose of forecasting is to minimize the risk in decision making and reduce unanticipated cost. One of the most important works of an electric power utility is to correctly predict load requirements. Load forecasting is a method of quantitatively determining future load demand. The primary function of a power utility is to supply electrical energy to the consumers economically. Limitations of energy resources in addition to environmental factors, requires that the electrical energy should be used more efficiently [1]. Load forecasting has a vital importance in power system energy management system. Precise load forecasting helps the electric utility to make unit commitment decisions, reduce spinning reserve capacity and schedule device maintenance plan properly. Besides playing a key role in reducing the generation cost, it is also essential to the reliability of power systems. Load forecasting plays an important role in power system planning, operation and control [5].

Power sector is highly capital intensive and entire planning of generation, transmission and distribution follows an axiomatic approach based on load forecasting. For this purpose, the anticipated load demand should be known. The resources available in the country for electrical power generation (thermal, hydro and nuclear power stations) can then be developed considering the electrical power and energy requirements and the locations or regions where demand is expected. Load forecasting is vitally important for the electrical industry in the deregulated economy. It has many applications including energy purchasing and generation, load switching, contract evaluation and infrastructure development. Short-term load forecasting is used to supply necessary information for the power system management in day-to-day operations and unit commitment. The forecasting time-period or prediction time for short-term load forecasting can be hour-by-hour, day-by-day, week-by-week [11].

The aim of this research work is Short-Term Load Forecasting of Chhattisgarh Grid by using the data obtained from State Load Dispatch Centre (SLDC) of Chhattisgarh State Power Transmission Company Limited (CSPTCL). Artificial Neural Network (ANN) is used to forecast the one day ahead load-demand requirement for Chhattisgarh grid. A complete database of load demand ranging from 5th March 2014 to 3rd March 2015 on daily 24-hour format, along with the maximum and minimum temperature data of each day of the required time period, is used for one day ahead load forecasting on date 4th march 2015. ANN based system has been modeled and implemented in MATLAB 2013 (a) to forecast the 24-hour load demand on required date. The hourly load forecast of 4th march 2015 is obtained by using the load-demand data of Chhattisgarh grid and Temperature data from 5th March 2014 to 3rd March 2015 respectively. The load forecast of 4th March 2015 obtained from ANN method is compared with the actual load of the same day obtained from SLDC, CSPTCL and average prediction error is calculated for determining the prediction accuracy of ANN used for short-term load forecasting.

II. ARTIFICIAL NEURAL NETWORK (ANN)

Artificial neural networks are essentially non-linear circuits that have the demonstrated capability to do non-linear curve fitting. The outputs of an artificial neural network are some linear or non-linear mathematical function of its inputs. The inputs may be the outputs of other network elements as well as actual network inputs. In practice network elements are arranged in a relatively small number of connected layers of elements between network inputs and outputs. Artificial neural networks have succeeded in

several power system applications, such as load forecasting, security analysis, fault diagnosis, planning, analysis, and protection. An artificial neural network is usually formed from many hundreds or thousands of simple processing units, connected in parallel and feeding forward in several layers. Because of the fast and inexpensive personal computers availability, the interest in ANN's has increased in today's world [13].
The ANN's ability in mapping complex non-linear relationships is responsible for its growing number of applications in short-term load forecasting. The research on artificial neural networks has been motivated right from its inception by the recognition that the human brain computes in an entirely different way from the conventional digital computer. The brain is a highly complex, nonlinear and parallel information processing system. It has the capability to organize its structural constituents, known as neurons, so as to perform certain computations many times faster than the fastest digital computer in existence today. The brain routinely accomplishes perceptual recognition tasks, e.g. recognizing a familiar face embedded in an unfamiliar scene, in approximately 100-200 ms, whereas tasks of much lesser complexity may take days on a conventional computer [10].
A neuron is an information processing unit that is fundamental element for the operation of an artificial neural network. The three basic elements of an artificial neuron model are:

(a) A set of weights, each of which is characterized by a strength of its own. A signal x_j connected to neuron k is multiplied by the weight w_{kj}. The weight of an artificial neuron may lie in a range that includes negative as well as positive values.

(b) An adder for summing the input signals, weighted by the respective weights of the neuron.

(c) Activation functions for limiting the amplitude of the output of a neuron. It is also referred to as squashing function which squashes the amplitude range of the output signal to some finite value [4].

$$v_k = \sum_{j=1}^{p} w_{kj}\, x_j \qquad .....(i)$$
$$y_k = \varphi(v_k + \theta_k) \qquad .....(ii)$$

Artificial neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyse. This expert can be used to provide projection given new situations of interest and answer "what if" questions [8].
The mathematical model of an artificial neuron is shown in the Figure 1:

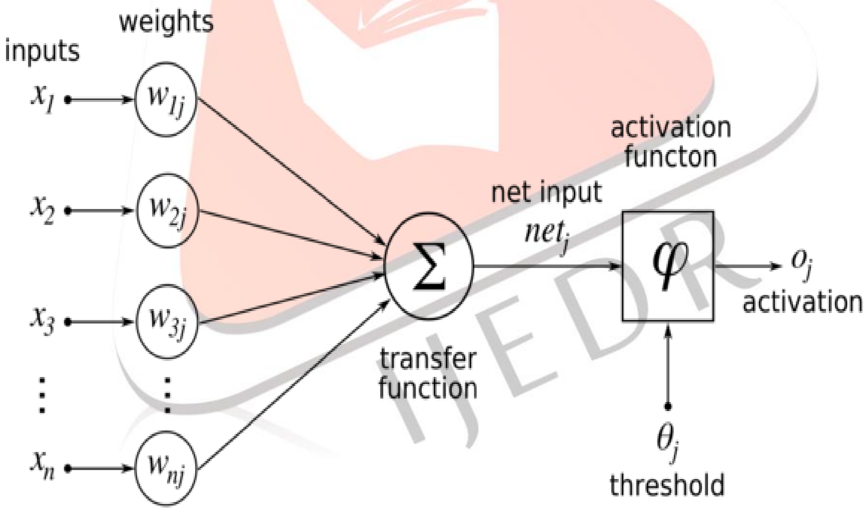

Figure 1 Mathematical model of an artificial neuron

Feed forward neural network consists of input layer, hidden layer and output layer. In a feed forward network, information always moves in one direction and it never goes backwards. Back-propagation learning algorithm is used for training these networks. During training, calculations are carried out from input layer towards the output layer, and error values are fed back to the previous layer. The most popular artificial neural network architecture for load forecasting is feed forward back propagation. This network uses continuously valued functions and supervised learning. Under supervised learning, the actual numerical weights assigned to element inputs are determined by matching historical data (such as time and weather) to desired outputs (such as historical loads) [6].
The structure of basic feed forward neural network is shown in the Figure 2. Signal system is allowed only from the input layer to the hidden layer and from the hidden layer to the output layer. Input variables come from historical data, which are date, hour of the day, past system load, temperature and humidity, corresponding to the factors that affect the load. The outputs are the forecasting results [2]. The number of inputs, number of hidden nodes, transfer functions, scaling schemes, and training methods affect the forecasting performance and hence must be chosen carefully. In applying an artificial neural network to load forecasting the user must select one architecture from a number of architectures (e.g. Hopfield, Back-propagation, Boltzmann machine), the number and connectivity of layers and elements, use of bi-directional or unidirectional links and the number format to be used by inputs and outputs [9].

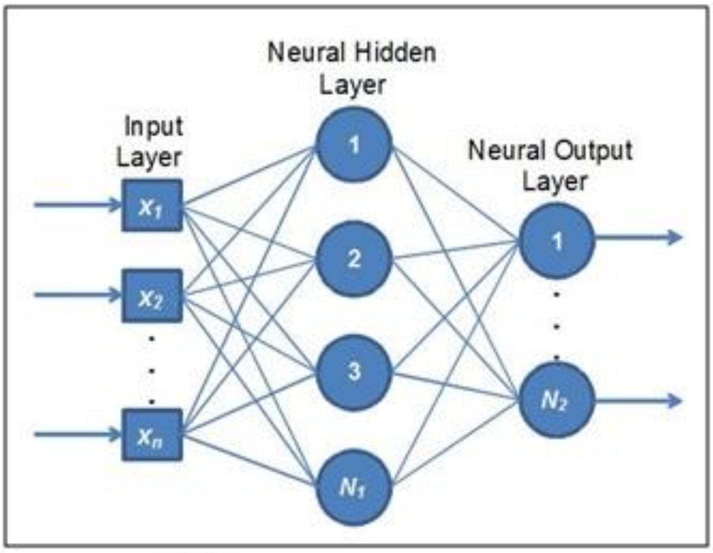

Figure 2 Structure of basic feed forward neural network

III. MODELLING AND DEVELOPMENT OF ANN BASED SHORT-TERM LOAD FORECASTING SYSTEM

The first and most important task for designing a system for one day ahead load forecasting is the identification of input parameters. Six unique inputs are used in this research work:

(1) Hour number
(2) Month number
(3) Day of the week
(4) Maximum temperature
(5) Minimum temperature
(6) Previous day load of same hour

One year load-demand data of Chhattisgarh grid from 5th March 2014 to 3rd March 2015 along with the maximum and minimum temperature data of each day has been employed for the training of the ANN to predict the 24-hour load on 4th March 2015. The structure of the proposed ANN based forecasting system is shown in Figure 3.

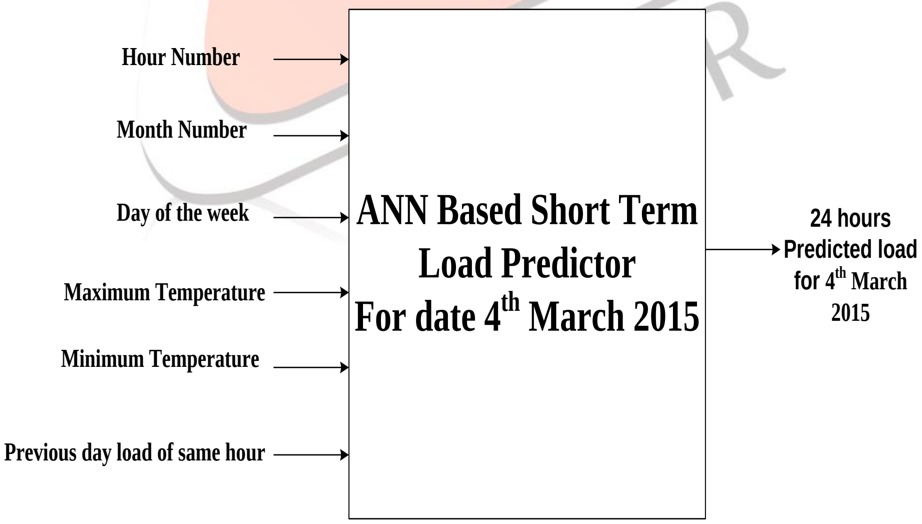

Figure 3 Structure of ANN based short term load forecasting system for date 4th March 2015

MATLAB 2013 (a) is used for ANN training and testing. The input and target data for the training and testing process is arranged as required for the modeling and development of proposed ANN predictor. The training data set for proposed ANN predictor contains all the six inputs and one target output all in separate columns. The training data set designed, contains all the six inputs and target output values for 365 days for 24 hours of each day. Hence the dimension of the developed dataset for training is 8736×7, i.e. it contains 8736 rows and 7 columns. Similarly a testing data set is also designed to test the prediction efficiency of the trained ANN, which includes all the six inputs for the date 4th March 2015 and having dimension of 24×6. After successful training and testing of proposed ANN predictor, the training and testing scenario and properties of the developed ANN predictor obtained are as follows:

(i) Name: VST_net_4_March
(ii) Network type: Feed-forward back propagation
(iii) Input data: dimension (6 × 8736)
(iv) Target data: dimension (1 × 8736)
(v) Training function: TRAINLM
(vi) Adaption learning function: LEARNGDM
(vii) Performance function: MSE
(viii) Number of layers: 3
(ix) Number of Hidden Layers:1
(x) Number of neurons in hidden layer: 200
(xi) Transfer Function for hidden layer: TANSIG

The structure of developed ANN predictor (feed forward neural network) is shown in Figure 4.

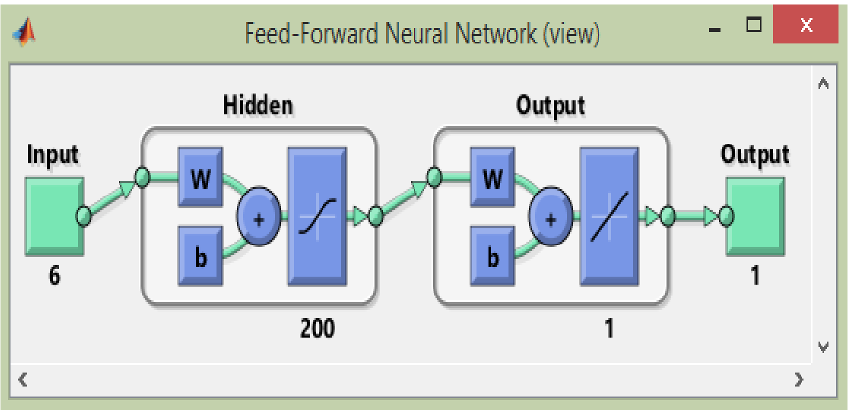

Figure 4 Structure of developed feed forward neural network

Figure 5 shows the plot between target points and input points for the training of ANN predictor.

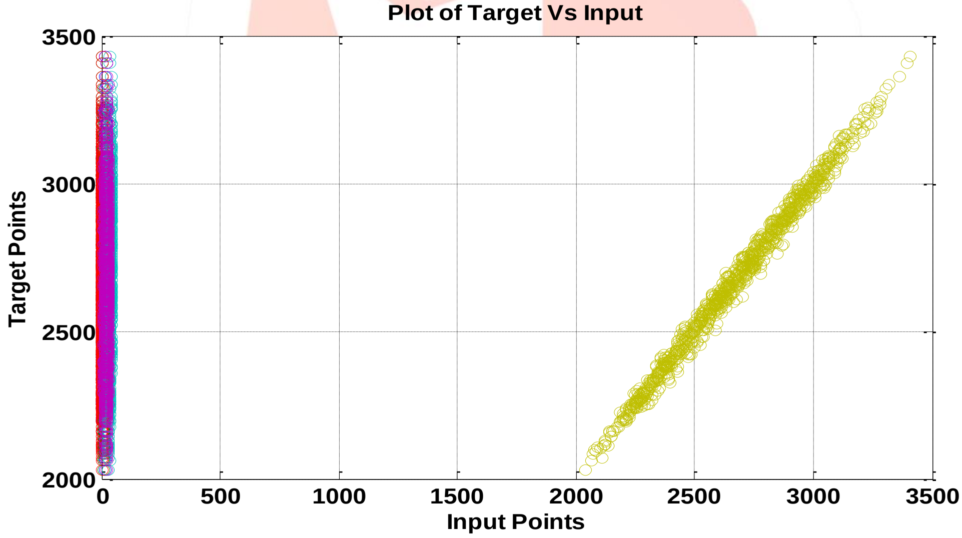

Figure 5 Plot of target data points vs input data points

Once the neural network has been structured for a particular application, that network is ready to be trained. To start the training process, the initial weights are chosen randomly. Then, the training, or learning, begins. Supervised training involves a mechanism of providing the network with the desired output either by manually grading the network's performance or by providing the desired outputs with the inputs.

The Training of ANN predictor is shown in Figure 6. After training of ANN predictor, the training error obtained is 0.00498.

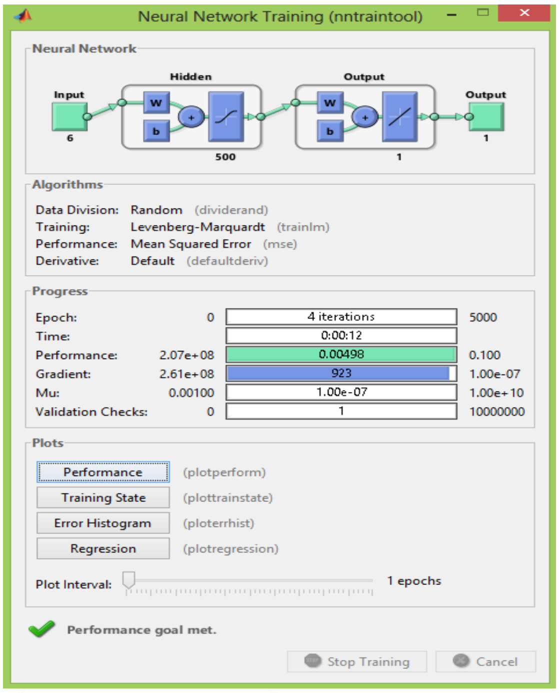

Figure 6 Neural network training process

The training performance plot is shown in Figure 7.

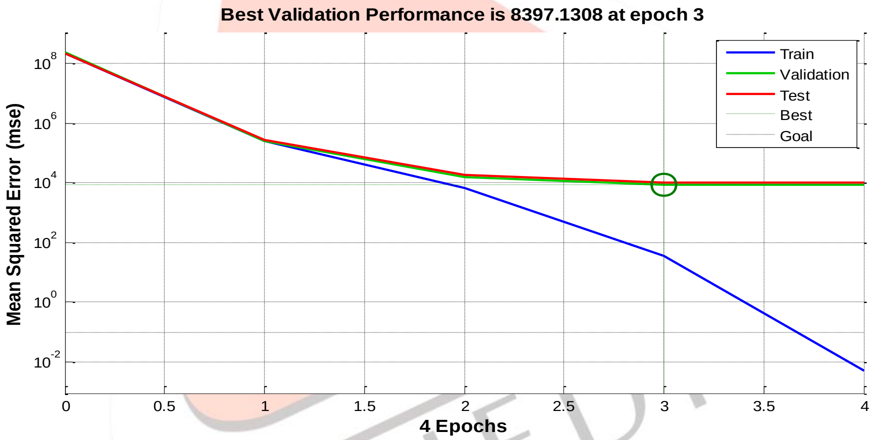

Figure 7 Training performance plot

The neural network predictor output after training is shown in Figure 8.

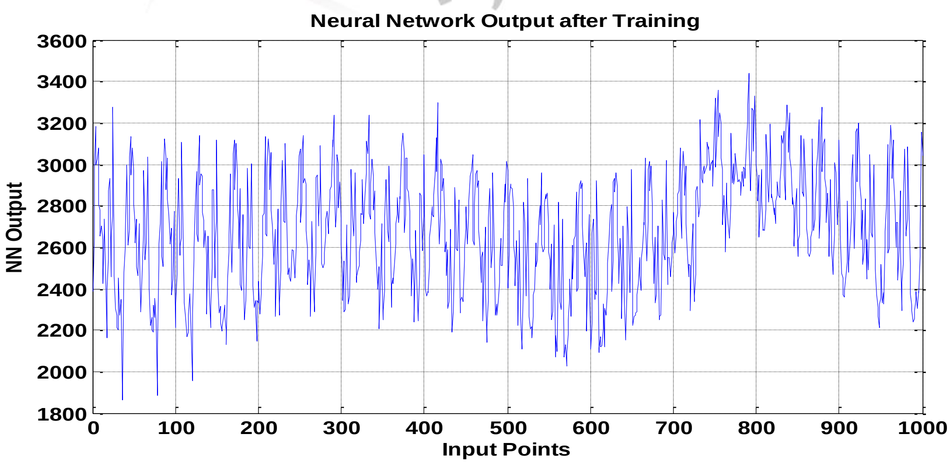

Figure 8 ANN predictor output after training

IV. RESULTS AND CONCLUSION

Short-Term Load Forecasting of Chhattisgarh Grid is performed successfully by using the data obtained from State Load Dispatch Centre (SLDC) of Chhattisgarh State Power Transmission Company Limited (CSPTCL). Artificial Neural Network (ANN) is used in MATLAB 2013 (a) to train and test the data obtained from SLDC, CSPTCL. The hourly load forecast of 4th March 2015 is obtained by using the load-demand data of Chhattisgarh grid from 5th March 2014 to 3rd March 2015 and the temperature data of same time period. Table 1 shows the actual load obtained from SLDC, CSPTCL on date 4th March 2015 and the forecasted load on the same date using ANN based prediction system along with the prediction error.

Table 1 ANN Load forecasting results on 4th March 2015

Hour No.	Actual Load in MW	Forecasted Load By ANN in MW	Difference in MW	Percent Prediction Error
1	2487	2904.479	417.479	16.786
2	2472	2827.010	355.010	14.361
3	2491	2765.956	274.956	11.038
4	2518	2689.863	171.863	6.825
5	2523	2733.969	210.969	8.362
6	2637	2868.119	231.119	8.764
7	2761	2969.117	208.117	7.538
8	2791	2972.120	181.120	6.489
9	2727	2982.938	255.938	9.385
10	2642	2963.467	321.467	12.168
11	2702	2955.987	253.987	9.400
12	2638	2909.612	271.612	10.296
13	2454	2777.959	323.959	13.201
14	2458	2562.262	104.262	4.242
15	2453	2528.526	75.526	3.079
16	2581	2555.435	25.565	0.991
17	2693	2704.757	11.757	0.437
18	2936	2856.475	79.525	2.709
19	3355	3185.594	169.406	5.049
20	3166	3040.258	125.742	3.972
21	3145	3184.913	39.913	1.269
22	2935	2650.304	284.696	9.700
23	2857	2728.918	128.082	4.483
24	2869	2740.187	128.813	4.490
Average percentage Prediction Error for 24 Hours in MW				7.293

The load forecast of 4th March 2015 obtained from ANN method is compared with the actual load of the same day obtained from SLDC, CSPTCL as shown in Figure 10. The Average Prediction Error of 7.293 % is obtained which is very low and it shows the high prediction accuracy of ANN used for short-term load forecasting.

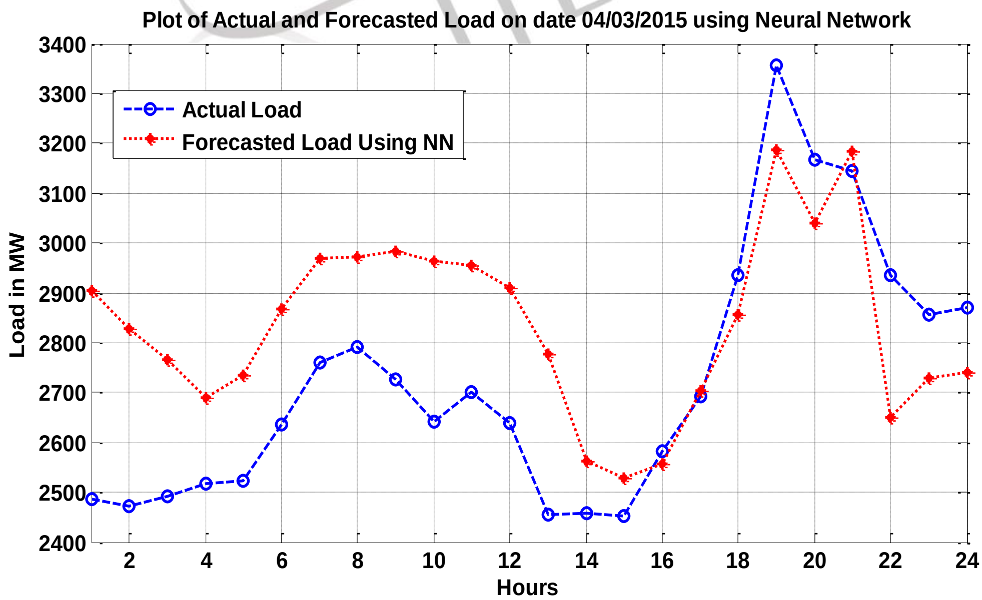

Figure 10 Plot of Actual load and Forecasted load on 4th March 2015 obtained by using ANN in MATLAB

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